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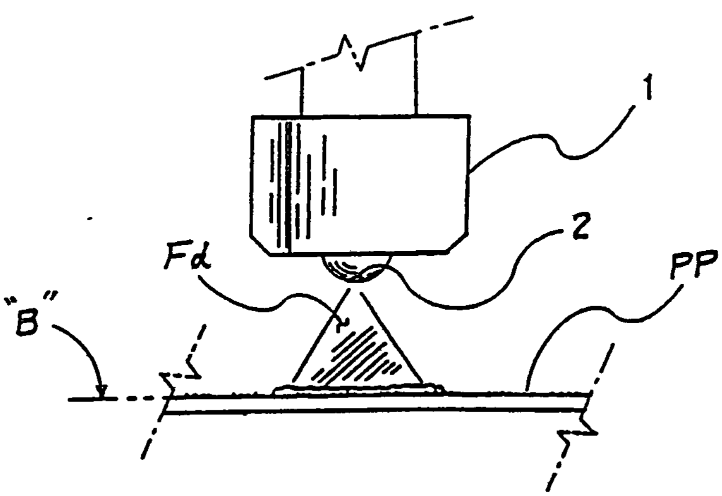
(54) Title: METHOD FOR APPLYING A FILM COATING OF A LIQUID HOT SOLDER RESIST AGENT AND A RESIST COMPOSITION FOR USE WITH THE METHOD



(57) Abstract

A method of applying a uniform thickness layer of hot solder resist on printed circuit board (PP) containing a raised pattern of conductive paths of predetermined thickness having edge surfaces disposed perpendicular to the upper surfaces of the raised conductive paths. The method includes emitting the hot solder resist in a dovetail flat fan liquid film (Fd) pattern from an airless spray gun (2), and locating the printed circuit board below the emitted dovetail liquid film pattern at a distance such that the upper surface of the printed circuit board intersects the dovetail liquid film above the point at which the liquid film starts to brake-up into liquid particles. The hot solder resist has a moderate viscosity and contains both high and low boiling point solvents to allow the coating to even out without unnecessarily thinning at points above the upper edges of the raised printed circuit conductive paths.

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METHOD FOR APPLYING A FILM COATING OF A LIQUID HOT SOLDER RESIST AGENT AND A RESIST COMPOSITION FOR USE WITH THE METHOD

Detailed Description of the Invention

Field of Industrial Application

The invention pertains to a method for applying a film coating of a liquid hot solder resist agent for wiring patterns on printed-circuit boards and a resist composition for the method.

Conventional Techniques

To apply a solder resist for a wiring pattern on a printed-circuit board, i.e., as a way to prevent the flow of molten solder from spreading in a soldering operation, a method of affixing a filmy hot solder resist to said board, the so-called dry film process, has been used increasingly of late. To sum up, this method affixes a film of the above-mentioned hot solder resist over the surface of a pattern consisting of a great number of wires, i.e., filiform copper foil, which has been imprinted on a printed-circuit board, consisting of through holds (holes in which to insert IC-attaching legs). A film (artwork) on which the required wiring pattern is drawn is

placed on the resist film and exposed to ultraviolet light, whereby the above-mentioned wiring pattern is cured, then the uncured section of the film except for the wiring pattern is peeled off, so that the above-mentioned wiring pattern is left on the printed-circuit board. Accordingly, the wiring pattern is left on the printed-circuit board. Accordingly, the wiring pattern is covered by the cured film and thus the flow of solder in soldering the IC legs inserted in the above-mentioned through holes can be prevented.

However, the above-mentioned dry film resist process is costly because it makes use of relatively expensive materials, and it is also very difficult to completely automate this process. For these reasons, other methods have been explored, and lately it has become customary for printed-circuit board makers to purchase a liquid hot solder resist then apply it directly.

The coating methods currently employed for the above-mentioned liquid hot solder resist include screen printing, roll coating, and curtain coating. However, there are various problems with these methods.

Before going into these problems, we will describe the high-density, fine structure of the printed-circuit boards to be treated by these methods. One recent example is a package-type DIP (dual inline package) that is being used most frequently at present, in which the distance between the component holes

(pins) is 100 mil (2.54 mm) as shown in Figure 6, and the degree of the fine pattern is represented by the number of wires to be placed in this space. Those with 2 wires are being produced in the largest numbers at present, but those with 3 wires are also in demand. These wires, of course, consist of printed filiform copper foil. A solder resist is formed in order to prevent molten solder from flowing and coming into contact with the copper foil wires when inserting the component (IC) legs in the through holes and soldering these legs, as shown in Figure 7.

We now describe problems that may be encountered when forming the above-mentioned solder resist, i.e., applying a liquid hot solder resist agent (hereinafter abbreviated as a liquid resist), by the above-mentioned methods.

(1) Screen Printing Method

This method is a so-called copying method which prints a liquid resist (Lsr) on a printed-circuit board (PP) placed underneath a screen (Sc) by pressing the liquid resist against the screen with a squeeze roller (R), as shown in Figure 11A. When pressing the liquid resist with the squeeze roller (R), localization or thinning (Lsr_3) of the coating occurs at the edges at the upper surfaces of the wires (copper foils), as shown in Figure 11B. Furthermore, there are various drawbacks such that the above-mentioned liquid resist does not penetrate well into the gaps between the

wiring patterns (WP) on the said board (PP), or conversely the liquid resist enters the through holes, which causes difficulty when removing the uncured liquid resist.

(2) Roll Coating Method

This method applies a liquid resist to a printed-circuit board using a roll (roller), and problems occur that are almost identical to those in the above-mentioned screen method.

(3) Curtain Coating Method

This method applies a film coating to a printed-circuit board (PP) by allowing a liquid resist to fall by its own weight in the form of a curtain (Fc) from a slit die, as shown in Figure 12. Accordingly, the whole upper surface of the wiring pattern (WP) is coated with the liquid resist, but layer-thinning at the edges as in the above-mentioned paragraph cannot be avoided. Furthermore, because the liquid resist falls in the form of a curtain, the resist is exposed to the air for a relatively long time, during which the solvent contained in said liquid resist evaporate, s, thus the concentration changes, and consequently, so does the thickness of the coating film. It is therefore necessary to install devices to constantly control these parameters, which add to the number of process steps and the facility cost.

Problems to be Solved

As described above, the conventional liquid resist coating operations result in layer-thinning at the edges over wiring patterns and also poor film formation between individual wiring patterns. Besides, any of these coating devices requires a relatively large number of process steps and are rather large in size and cost.

The incentive for the present invention was in solving these problems and in forming a better solder resist more simply.

An Approach to Solving the Problems

The main feature of the invention is to provide a method for applying a liquid hot solder resist agent in the form of a film from an airless spray nozzle, as well as an actual liquid hot solder resist agent that is suitable for said method.

The above-mentioned film-forming coating process with an airless spray nozzle is described below.

Originally, liquid spraying was a process for applying a coating by ejecting a liquid from a nozzle, atomizing said liquid, and making the atomized particles adhere to the surface of a material in the form of a uniformly thick film. There are two spraying methods, i.e., air spraying and airless spraying. In the former method, a liquid is sucked into a pipe according to Bernoulli's theorem when air passes

through said pipe at high speed, and said liquid is ejected into the air from a nozzle and atomized according to the expansion and diffusion of the air, or said liquid is ejected from a nozzle under high pressure and air is immediately blown against the ejected liquid stream, so that said stream is broken into pieces and atomized. The latter method pressurizes the liquid to several tens of kg/cm^2 without using air at all, where said compressed liquid is atomized simultaneously as it undergoes rapid expansion and diffusion when it is ejected into the air through a nozzle orifice.

In the above-mentioned airless spraying, however, when the liquid is ejected from a nozzle, especially from a flat spray nozzle, it is not atomized for some distance from the orifice, but instead forms dovetail-shaped film as shown in Figures 1A and 1B. This is called a "dovetail" phenomenon, in short, a "tail" phenomenon. The distance " " of the dovetail from the nozzle orifice depends on the characteristics of the liquid, but it is experimentally confirmed that this distance is proportional to the viscosity of the liquid and inversely proportional to the pressure force applied to the liquid, which is the same with regard to any liquid. The distance " " ranges from a minimum of about 3 mm to a maximum of about 20 mm.

The essential part of the invention comprises ejection of a liquid resist from an airless

spray nozzle (1) as shown in Figure 2, with application of said resist taking place at the bottom ("B" line) of the dovetail-shaped liquid film (Fd) of the resist that is in contact with the surface of the printed-circuit board(PP), as shown in Figure 3.

This method will now be described in further detail. As described above, the distance " " of the dovetail-shaped liquid film between the nozzle orifice (2) and the bottom line "B", differs with the characteristics of the liquid being used, but it is enough for the distance " " to be about 5 mm when coating the surface of a printed-circuit board.

General liquid resists have a viscosity of about 400 cps, and a distance " " of about 2 mm at a liquid pressure of 60 kg/cm^2 when such a resist is used. However, because the above-mentioned viscosity causes a problem when a liquid resist is used in the invention method, a further improved resist must be used. This point will be described later.

The merits when a liquid resist is applied to the printed-circuit board surface along the "B" line at a dovetail length of about 5 mm are described below. The reader should refer to Figures 4 and 5. This method appears, at a glance, to bear a close resemblance to the known curtain coating method (Figure 12A), but actually differs greatly. The differences can be listed as follows.

(1) In the curtain coating method, the film hangs down in the form of a curtain (Fc) and reaches the surface of the printed-circuit board (PP) by its own weight, adhering to said surface. Accordingly, the exerted pressure force for adhesion is only the actual weight of said liquid film and is extremely weak. That is, the liquid film rests only lightly on the printed-circuit board surface, thus the film sometimes enfolds air; it is also difficult to make the film penetrate deep into the fine uneven gaps.

As opposed to this, the invention method provides a moderate ejection force to the liquid from the nozzle orifice (2), and this force propels the liquid against the printed-circuit board (PP) as shown in Figures 2-5. However, this force is not so large as to reflect or scatter the liquid, but is enough to press the liquid against said board; thus the liquid is pressed, expends, penetrates into the fine uneven gaps, and also covers the side surfaces of the copper foil. Therefore, a perfect coating will be formed.

(2) The curtain coating method cannot sufficiently coat the vertical side surfaces of the filiform copper foil used as printed wires. As can be seen in Figure 12, the curtain drops vertically and thus the liquid resist does not adhere well to the side surfaces of the copper foil, which are parallel to the curtain.

In the invention method, however, the liquid resist (Lsr) is sprayed radially downward as shown in Figure 8, thus the liquid layer Lsr_1 adheres evenly to the side surfaces of the copper foil being used as printed wires (WP).

(3) In the curtain coating method, the liquid film adheres to the top surfaces of the copper foil but thins (Lsr_4) at both edges of said copper foil, as it flows down by its own weight along the edges at the top surfaces of the copper foil.

In the invention method, on the other hand, a filmy disordered layer (Lsr_1 in Figure 8) is formed as a result of the impingement of the liquid film as described in the above paragraph (1), and hence the flow of the film in one direction as mentioned above does not occur so easily, so that the layer thinning mentioned above is less likely to occur. In addition, because a liquid resist with a moderate viscosity is used, as will be described later, the phenomenon of the resist flowing down from the copper foil surface is reduced.

(4) In the curtain coating method, the liquid film (Fe) is exposed to the air for a relatively long period while it falls from the slit opening so that the volatile components in said liquid evaporate, and this evaporation is extremely unstable as it is largely influenced by room temperature or other temperatures.

In the invention method, the liquid is ejected from a nozzle, so the ejection time is very short and accordingly the variation in the amount evaporated is small. Furthermore, because the liquid is circulated through a closed system and ejected from a nozzle installed within said system, as shown in Figure 10, the proportion of volatile components can be maintained constant and an unvarying coating can always be applied.

(5) In the curtain coating method, the width of the film discharged is determined by the slit width, but in the invention method, this width is about 10 mm and the width of the printed-circuit board to be coated can be covered by automatically passing this width over the board several times.

In addition, the equipment according to the invention method has many advantages including reduced facility cost.

However, when applying a liquid resist coating with the above-mentioned airless spray nozzle, it is desirable to use a liquid resist whose composition is most suited to the said method. This composition is described in detail below.

Liquid hot solder resist agents originally contained a relatively large amount of volatile solvent. Of the volatile solvents used, there are those with high boiling points and those with low boiling points. The boiling point differences have a

large effect on the liquid resist coating film applied to the printed-circuit board.

For example, when the resist agent contains a high-boiling volatile solvent, the liquid resist applied to a printed-circuit board will form a film over an uneven pattern on said board, as shown in Figure 13, but the film flows with the passage of time (about 1 minute), resulting in uneven thickness, as shown in Figure 14, and then sets in this state. This thinning of the film is not desirable.

When the resist agent contains a low-boiling volatile solvent, the same state as mentioned above (refer to Figure 13) is produced at the time of coating, but the volatile component immediately evaporates and the film sets in roughly the same state it was in immediately after coating (Figure 13). That is, practically no evening out takes place. This is also undesirable.

It is preferred that levelling out occurs to a moderate degree. In order to achieve this, we conducted various experiments by mixing a high-boiling solvent and a low-boiling solvent in different proportions and obtained relatively good results with the following composition, namely:

(a)	photosensitive epoxy resin	20%
(b)	curing agent (containing fine talc powder and alumina) as a component mixed in the main solvent and an additive	4%

(c)	Cellosolve acetate as the high-boiling solvent	26%
(d)	ethylene glycol methyl ether as the high-boiling solvent	20%
(e)	methyl ethyl ether as the low-boiling solvent	30%

The deficiencies of a resist containing a single solvent as mentioned earlier can be compensated for by a composite resist in which a high-boiling solvent and a low boiling solvent are mixed, as described above. That is, a satisfactory coating (Lsr_2) in which the liquid resist properly levels out (refer to Figure 9) can be formed on the printed-circuit board surface.

One example of data in film-forming coating experiments for the liquid resist of the above-mentioned composition is as follows:

(1)	liquid resist:	The above-mentioned composition
(2)	liquid resist viscosity:	30 cps
(3)	liquid pressure:	1.7 kg/cm^2
(4)	nozzle:	Nordson cross-cut nozzle (orifice diameter, 0.18 mm)
(5)	ejected amount	20 L/min
(6)	pattern size	length of the dovetail, 5 mm width of the dovetail, 8 mm
(7)	distance from the nozzle to the printed-circuit board:	4 mm
(8)	repeated scanning width in coating	6 mm

(9) coating speed: 24 mm/sec

(10) coating thickness (refer to Figure 9):

(a)	on the printed board:	35	1
(b)	on the pattern (on the printed wires (WP)):	20	1.5
(c)	at the edges of the wires (WP), i.e., the copper foil:	10	2

The above data are only one example. Satisfactory results were obtained even under the following varied conditions. That is, the suitable viscosity for the above-mentioned item (2) is in the range of 20-50 cps. Good results were also obtained at a liquid pressure (item (3)) of 1 kg/cm^2 for a low viscosity of 10 cps, at 3 kg/cm^2 for a high viscosity of 100 cps, and at 4.5 kg/cm^2 for a high viscosity of 150 cps (the orifice diameter is 0.15 mmø).

Preferably, the liquid hot solder resist composition contains a nonvolatile component whose content is adjusted to 10% to 40% and a volatile solvent component that is a composite of high-boiling components with boiling points of 100°C to 210°C and low-boiling components with boiling points of 30°C to 100°C, the mixing weight ratio for this composite solvent being adjusted to 40% to 95% for the high-boiling solvent and 60% to 5% for the low-boiling solvent.

Advantages

According to the method and the composition of the invention, a liquid hot solder resist agent coating that is uniformly thick and that levels out can be applied to a high-density printed-circuit board; thus the invention will contribute greatly by improving the soldering operation efficiency for said printed-circuit boards and by improving the quality of the printed-circuit boards.

Brief Description of the Figures

Figure 1A is a front view of the dovetail phenomenon in airless spraying, which is to be utilized in the invention. Figure 1B is a side view of Figure 1A. Figure 2 is a diagram illustrating the bottom section of the above-mentioned dovetail, which is to be utilized in the invention. Figure 3 is a diagram illustrating the state of applying the above-mentioned dovetail bottom section to a printed-circuit board to form a coating film. Figure 4 is an oblique view of Figure 3. Figure 5 is a diagram illustrating the state of applying a flat coating by scanning the printed circuit board to sequentially apply plural overlapped ribbons of coating. Figure 6 is a plan view of one example of a high-density printed wiring pattern (DIP). Figure 7 is a side cross-sectional view of Figure 6. Figure 8 is a diagram illustrating the state of applying a liquid hot solder resist agent

over a printed wiring pattern, according to the invention. Figure 9 is a diagram illustrating the levelled out and set state of Figure 8, after coating. Figure 10 is a system diagram of the closed system of airless spray equipment used in the invention. Figure 11A is a front view of a known screen printing device. Figure 11B is an enlargement of section "E" in Figure 11A. Figure 12A is a front view of a known curtain coater. Figure 12B is an enlargement of section "F" in Figure 12A. Figure 13 is a diagram illustrating the state immediately after a liquid hot solder resist agent containing a high-boiling solvent is applied to a printed-circuit board. Figure 14 is a diagram illustrating the set state after about 1 minute, for Figure 13.

Description of Major Symbols

(1) airless spray nozzle; (Fd) dovetail-shaped liquid film; (Lsr) liquid hot solder resist agent; (PP) printed-circuit board; and (WP) wiring pattern.

CLAIMS

1. A method of applying a uniform thickness layer of hot solder resist on a printed circuit board containing a pattern of conductive paths, comprising the steps of:

emitting a liquid stream of hot solder resist from the orifice of an airless spray gun in a dovetail-shaped flat fan liquid film pattern having a lower edge below which the liquid film breaks-up into liquid particles,

locating the printed circuit board below the airless spray gun orifice at a distance such that the upper surface of the printed circuit board intersects the dovetail-shaped liquid film above the lower edge thereof below which the dovetail-shaped liquid film breaks-up into liquid particles, and

moving the spray gun orifice and printed circuit board transversely relative to each other such that different portions of the printed circuit board are successively impinged with the dovetail-shaped liquid film of hot solder resist to thereby sequentially coat said different portions of said printed circuit board.

2. The method of claim 1 wherein said locating step includes locating the printed circuit board approximately 4 mm below the airless spray gun orifice, and the emitting step includes emitting a dovetail liquid film having a height of about 5 mm defined by the distance between the orifice and the lower edge of the dovetail liquid film

3. The method of claim 2 wherein the emitting step includes emitting a liquid resist having a viscosity of approximately 30 cps at a pressure of approximately 1.7 Kg/cm^2.

4. The method of claim 3 wherein the emitting step includes emitting the liquid resist through a cross-cut nozzle having an orifice of approximately 0.18 mm diameter.

5. The method of claim 1 wherein the emitting step includes emitting a liquid resist containing a mixture of solvents of differing boiling points.

6. The method of claim 5 wherein the emitting step includes emitting a liquid resist in the approximate viscosity range of 10-150 cps at a pressure of approximately 1-4.5 Kg/cm^2.

7. The method of claim 1 wherein the emitting step includes emitting a liquid resist containing a nonvolatile component in the approximate weight percentage range of 10%-40% and a volatile solvent component in the approximate weight percentage range of 60%-90% that is a composite of high-boiling point solvents in the approximate boiling point range of 100°C - 210°C and low-boiling point solvents in the approximate boiling point range of 30°C - 100°C, with mixing weight ratio for the composite solvent being adjusted between the approximate range of 40%-95% for the high-boiling solvents and 5%-60% for the low-boiling solvents.

8. The method of claim 1 wherein the emitting step includes emitting a liquid resist containing approximately 20% by weight of ethylene glycol ether and approximately 30% by weight of methyl ethyl ether and approximately 25% by weight of Cellusolve acetate.

9. The method of claim 1 wherein the emitting step includes emitting a liquid resist having composite solvent including at least one solvent having a relatively low boiling point and at least one solvent having a relatively high boiling point, and wherein the method includes providing a printed circuit board with a raised pattern of predetermined thickness conductive paths on the surface thereof which have edge faces and top faces disposed perpendicularly relative to each other, whereby the resist coating applied to the printed circuit board evens out over the top faces of the raised pattern of conductive paths provided on the surface of the printed circuit board without unnecessarily thinning at points above the upper edges of the raised printed circuit conductive paths.

10. The method of claim 9 wherein said emitting step includes emitting said liquid resist over a range of directions to substantially uniformly coat both the edge and top faces of the conductive paths.

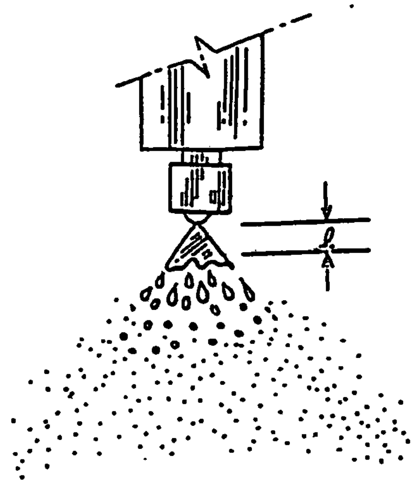

FIG. 1A

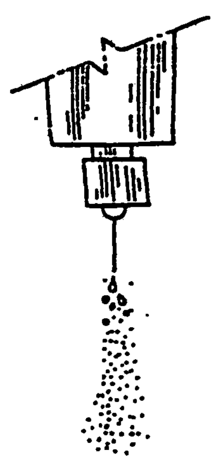

FIG. 1B

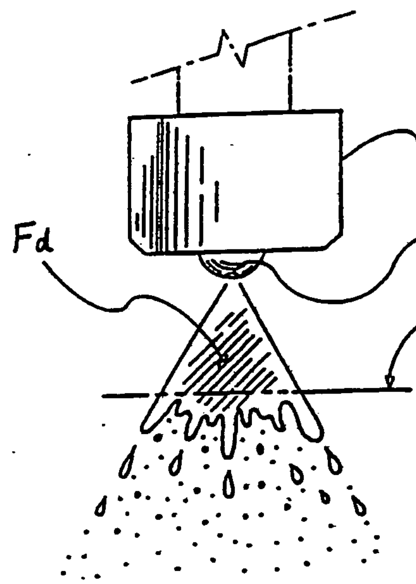

FIG. 2

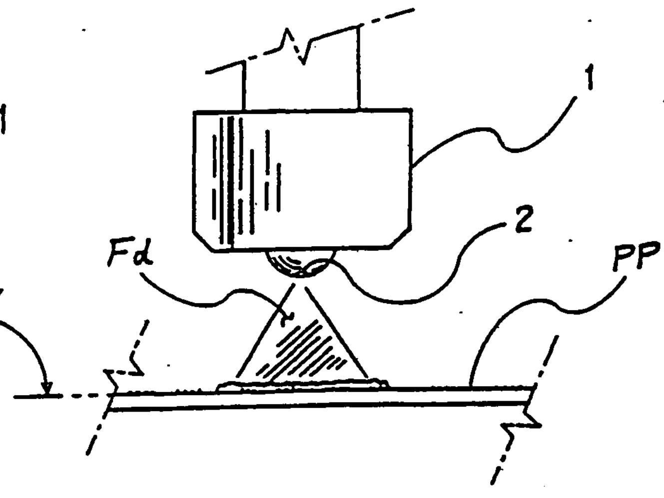

FIG. 3

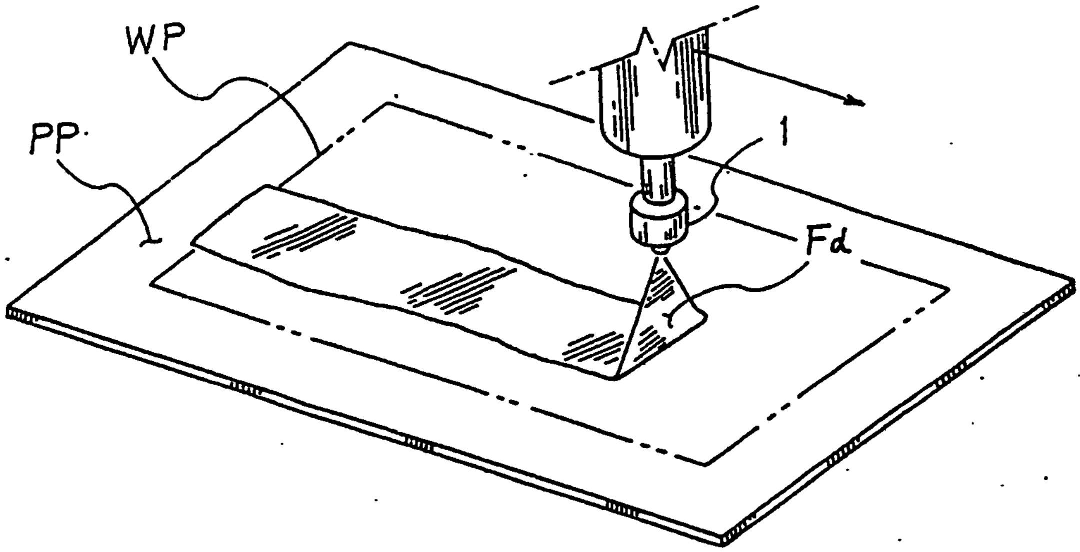

FIG. 4

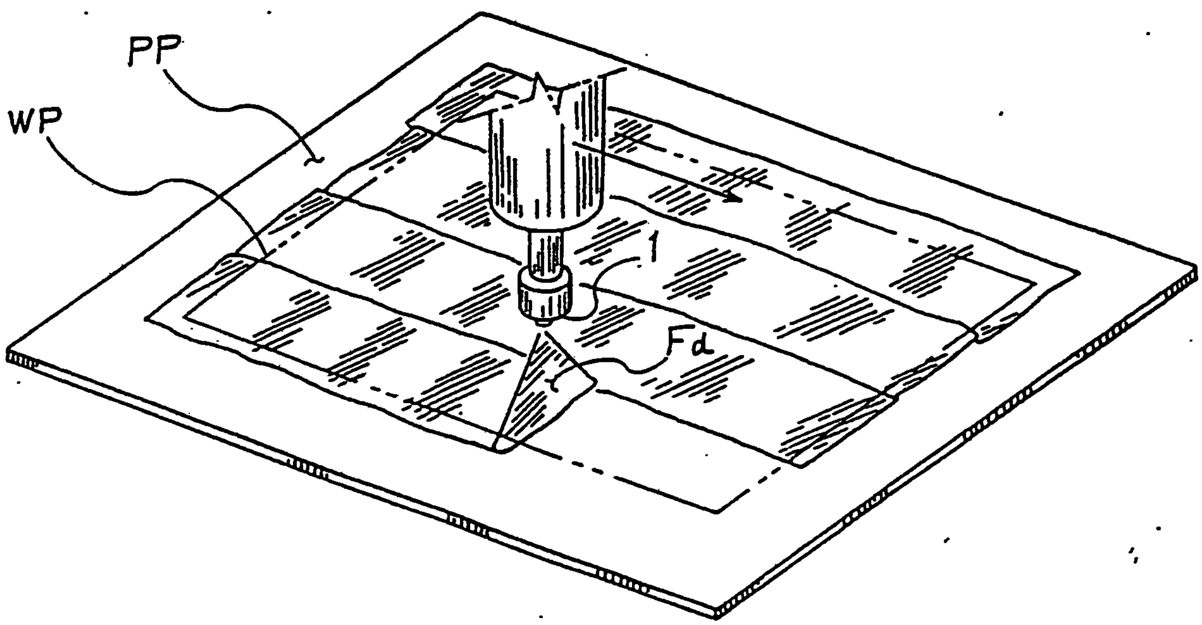

FIG. 5

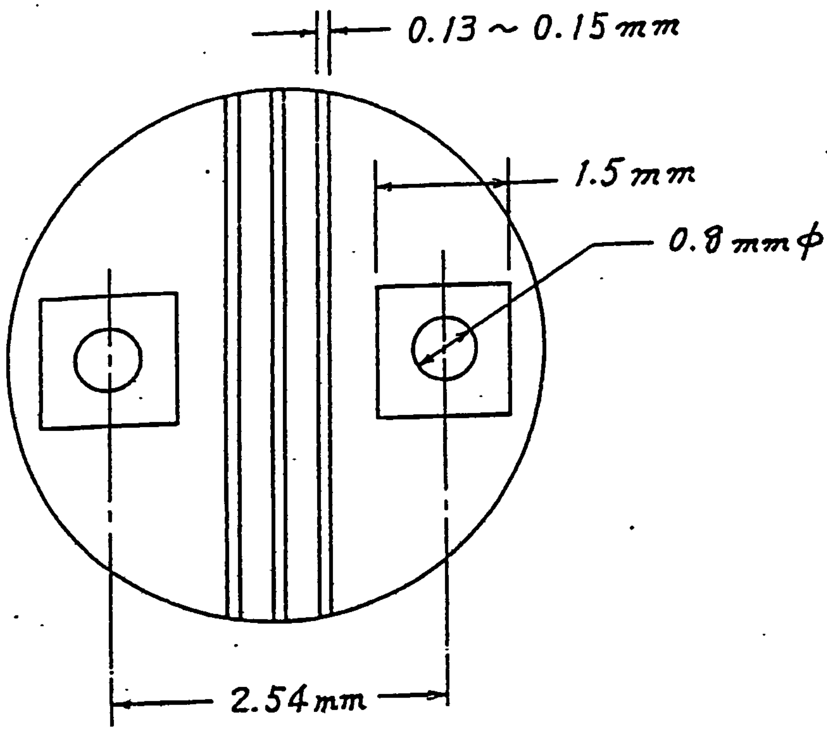

FIG. 6

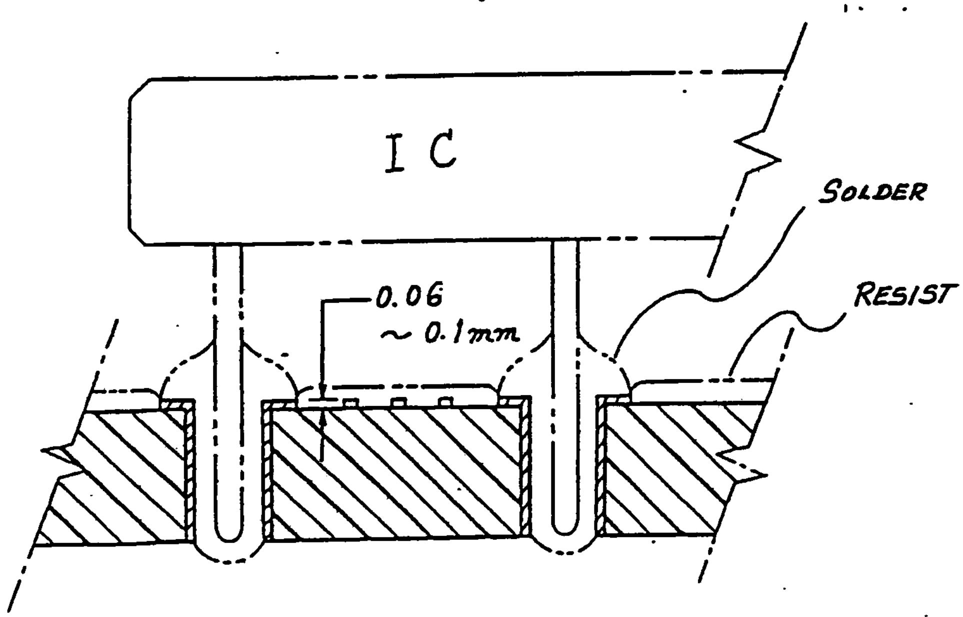

FIG. 7

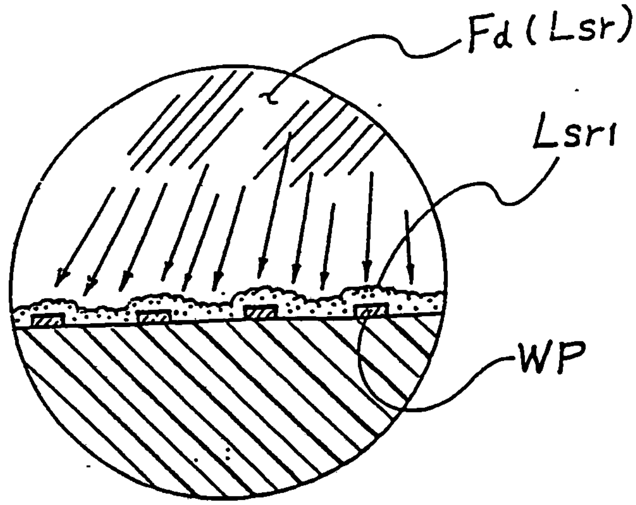

FIG. 8

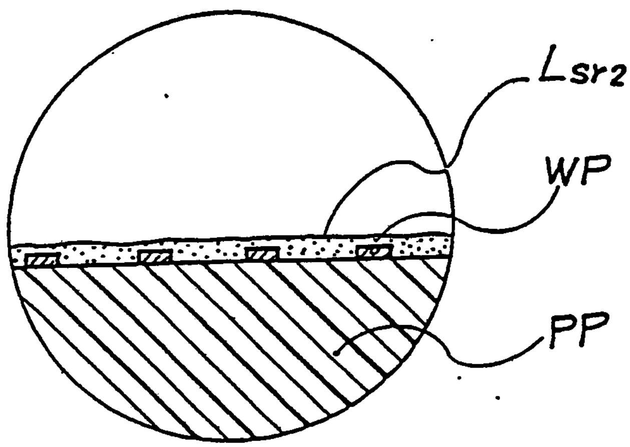

FIG. 9

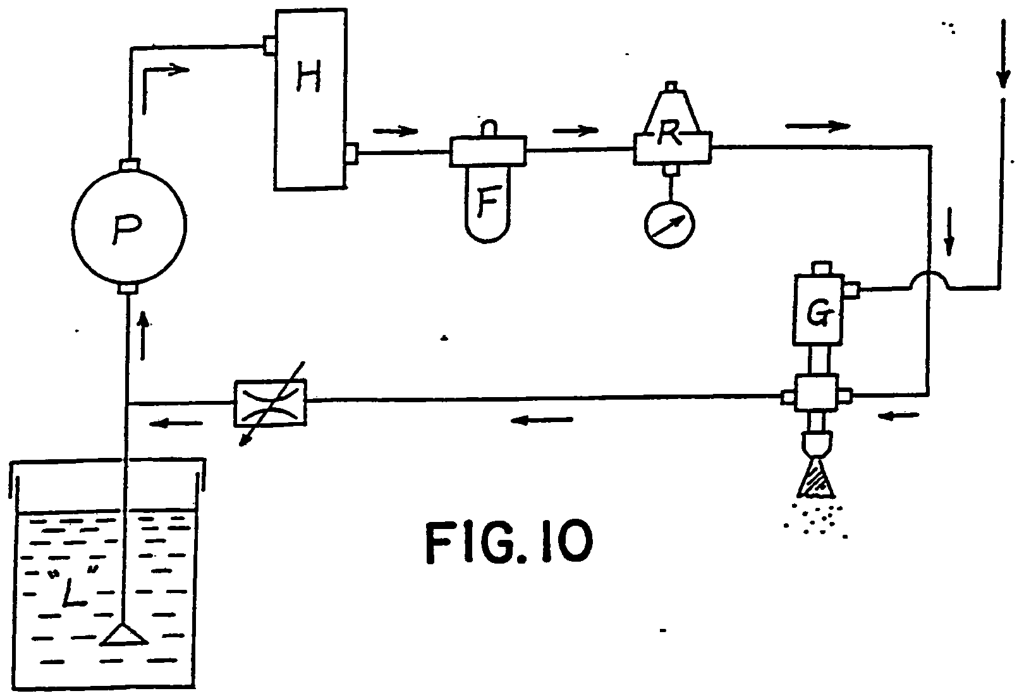

FIG. 10

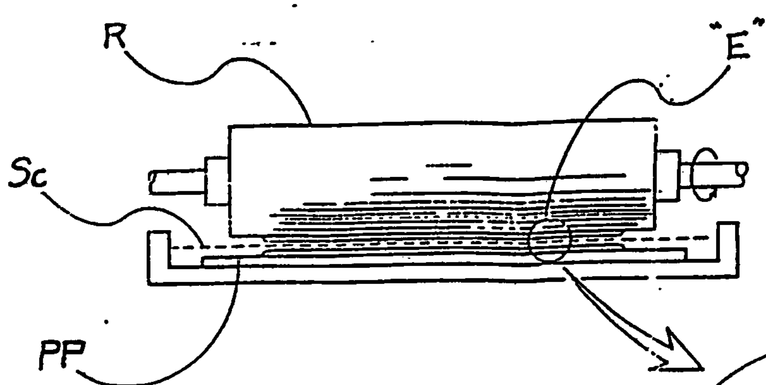

FIG. 11A

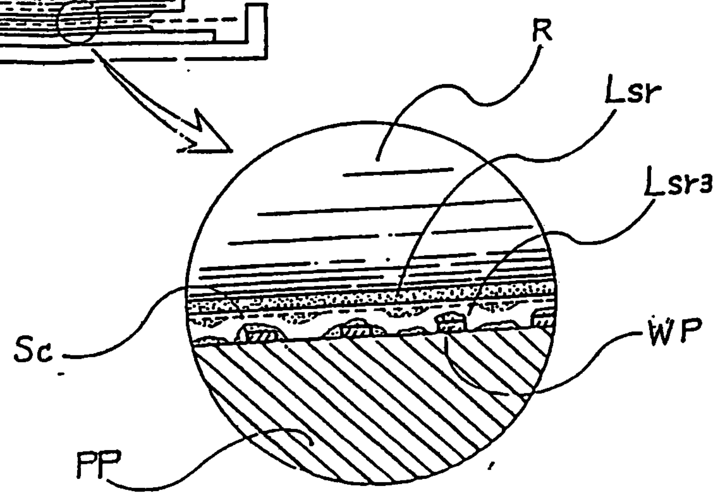

FIG. 11B

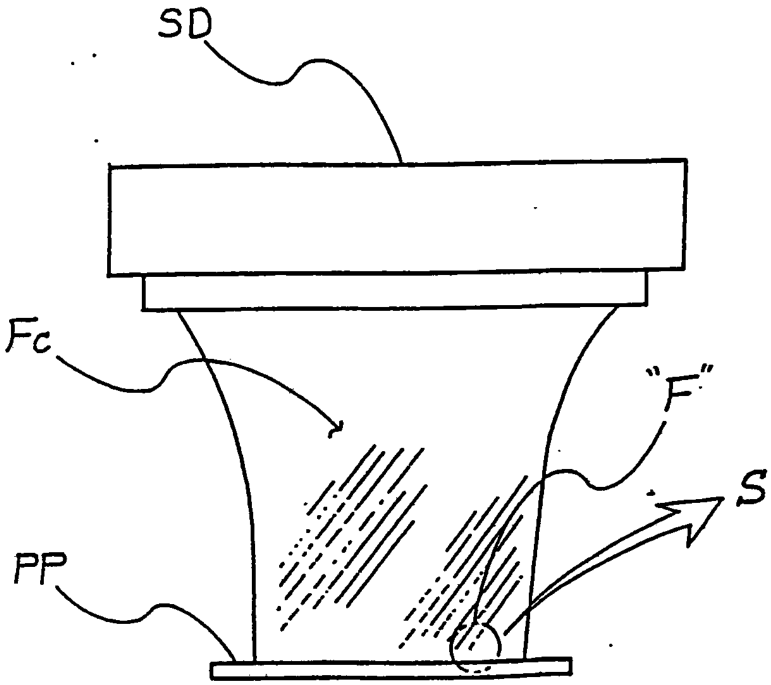

FIG. 12A

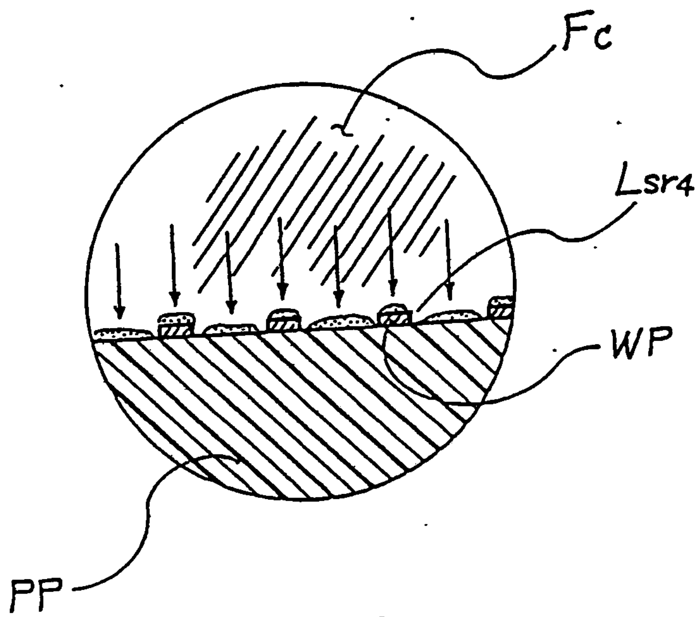

FIG. 12B

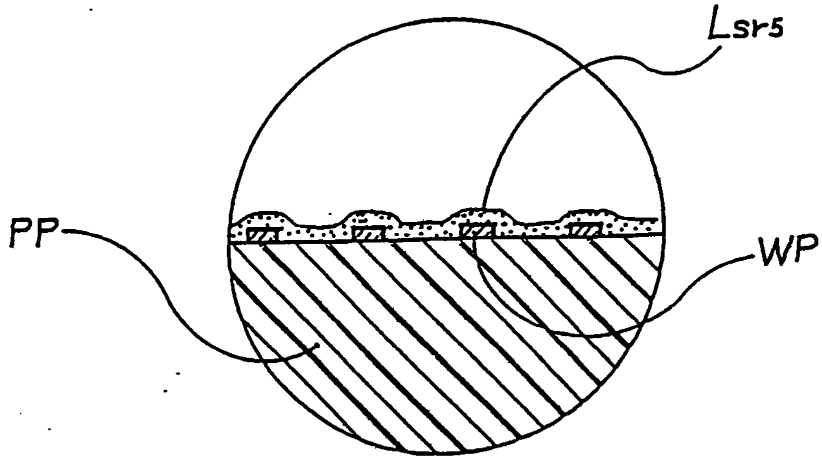

FIG. 13

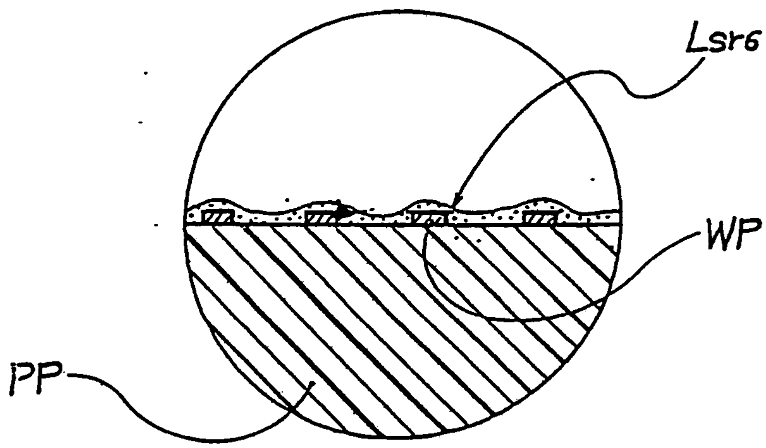

FIG. 14

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US88/03044

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC (4). C23C 26/00
US CL. 427/96, 420, 421, 207.1

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
US	427/96, 420, 421, 207.1

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
Y,P	US, A, 4,753,819 (SHIMADA) 28 June 1988. See column 3, lines 14-24, 28-32, 51-54; column 4, lines 35-37; column 8, lines 3-16; claim 4.	1-10
A	US, A, 4,600,601 (TAMURA) 15 July 1986.	

* Special categories of cited documents: [10]
"A" document defining the general state of the art which is not considered to be of particular relevance
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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
05 October 1988	29 NOV 1988
International Searching Authority	**Signature of Authorized Officer**
ISA/US	Vi Duong Dang VI DUONG DANG